A PLANNING MODEL OF A CREAMERY

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A Planning Model of a Creamery

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TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	ii
LIST OF TABLES	iv
LIST OF FIGURES	v
CHAPTER 1 INTRODUCTION	1
CHAPTER 2 MATRIX SECTOR SELECTION	2
CHAPTER 3 PRODUCT FLOW PATTERNS	8
CHAPTER 4 PROGRAM TO GENERATE MATRIX	20
CHAPTER 5 EXAMPLE OF USE OF MATRIX	27
CHAPTER 6 SUMMARY AND CONCLUSIONS	32
APPENDIX A	42

LIST OF TABLES

Table		Page
1	Sector Definitions and Product Composition Assumptions	7

LIST OF FIGURES

Figure		Page
1	Design of Augmented System Matrix	5
2	Flow Diagram of Creamery System	10
3	Typical Program Output, Information Page	21
4	Typical Program Output, Product Pounds Transactions Matrix	22
5	Typical Program Output, Butterfat Pounds Transactions Matrix	23
6	Typical Program Output, SNF Pounds Transactions Matrix	24
7	Information Page - Example	29
8	Product Pounds Matrix - Example	30
9	Typical Technical Coefficients Matrix, Product Pounds Model	33
10	Typical Interdependency Coefficients Matrix, Product Pounds Model	37

CHAPTER 1

INTRODUCTION

Many creameries are operated by managers who, through experience, have generated rules of thumb that are very accurate for predicting product flows and input requirements to meet estimated demand. As the number of different products grows, however, the task becomes more difficult. Therefore, a model in matrix form showing the flows of different products of a creamery is a useful management tool. With such a matrix, managers can be much more flexible in using forecasted consumer demand to predict internal flow volumes and raw material requirements. The matrix, when converted to butterfat pounds as the flow unit, could also be used as a comparison (or as a source) for the butterfat accounting which is required by most regulatory agencies. If the matrix were set up in the proper format, it could be used as a basis for a linear flow model similar to advanced economic models which would give management an additional tool for strategic planning.

This paper demonstrates the construction of a flow matrix in its basic form for The Pennsylvania State University Creamery. It presents an example of use of the matrix as a planning tool. Finally, it presents thoughts on the future development of such models.

CHAPTER 2

MATRIX SECTOR SELECTION

The first step in the construction of a flow matrix, which is usually called a transactions matrix in input/output analysis, is the selection of the sectors which represent the initial, intermediate, and final products of the creamery. The initial products are the raw materials the creamery must purchase or grow. In many cases there are alternative materials or alternative sources for the same material which could be used and a sector should be selected for each alternative.

For example, the Penn State Creamery has contracted for the milk production of several producers. However, it also purchases raw milk on the open market when necessary. Therefore, a sector for "contracted raw milk" is designated and also one for what is called "extra raw milk". Cream is sometimes available in the local area and, therefore, a sector is designated "extra cream". The word "extra" is used to indicate raw materials beyond those already contracted. An additional sector designated "dry milk solids" completes the selection of sectors for milk related raw materials.

Non-milk related raw materials would include many materials added to the process in producing milk products. However, in the interest of clarity, many additives are neglected in this paper because of their small volume. A sector is designated for "water", which is used primarily for making sherbert and for conversion of dry milk

solids to condensed skim milk. In practice, the dry milk solids would not be mixed with water, but the technique is used in this paper to standardize the production formulas. Also, sectors are designated for other high volume additives such as "sugar," "dextrose," and "cocoa." In practice, it might be advantageous to include sectors for such items as stabilizers, emulsifiers, and other small volume additives. These sectors would add completeness to the matrix.

The manufacture of milk products usually involves the use of several intermediate products. For example, the raw milk is usually separated into cream and skim milk which are then used in various combinations to make different products. It should be noted that separation is not always done completely. If the end product is a fluid milk product often the separator is adjusted to produce an output of a given butterfat content, rather than complete separation. This can be accounted for in the model by adding skim milk to the raw milk.

In the Penn State Creamery, cream is a basic intermediate product and a sector entitled "cream" is designated. This is often called cooler cream since it is stored in ten gallon cans in a cooler until used. "Skim milk" is another intermediate sector even though it is produced as an end product. Skim milk which is not used right away is usually condensed for storage and "condensed skim milk" is used to add milk solids to a product without adding too much volume. Finally, many milk products require some kind of culture added during processing. This is usually done by culturing skim milk in the form of "buttermilk". Buttermilk which is sold as a product is usually creamed and will be given a sector in the finished product section.

The remainder of the sectors are assigned to the finished products of the creamery. For the Penn State Creamery these include "homogenized milk," "chocolate milk," "creamed buttermilk," "half-n-half," "butter," "ice cream mix," "ice cream," "ice milk mix," "sherbert," "sour cream," "cream cheese," "cottage cheese," and "cheddar cheese." The difference between ice cream and ice cream mix is the density. During the freezing process air is added to the ice cream mix. Both products are sold by the Penn State Creamery.

This completes the system. The 25 sectors already named account for all the flows within the creamery. A 25 x 25 matrix as shown in Figure 1 could be generated at this point for the system, indicating the interaction between sectors. However, a more useful matrix is formed if the system is augmented by sectors added to designate output destinations, usually called closure sectors in input/output analysis. Accordingly, sectors are designated for "shrinkage" (or losses during processing), "whey," "inventory," and "output." In a commercial enterprise, it would probably be useful to further break down output into home delivery, supermarket sales, institutional sales, and any other external destination of interest to management. However, in this case, the university takes nearly all of the production.

Therefore, the system and its output can be described by a 29 x 25 matrix; but for use as a linear flow model later, it is convenient to make the matrix square. To do this, four columns of zeros are added to the matrix and a 29 x 29 augmented matrix is formed as shown in Figure 1.

Finally, to complete the model, an input vector is added as a column to the matrix to indicate inputs from the external world into

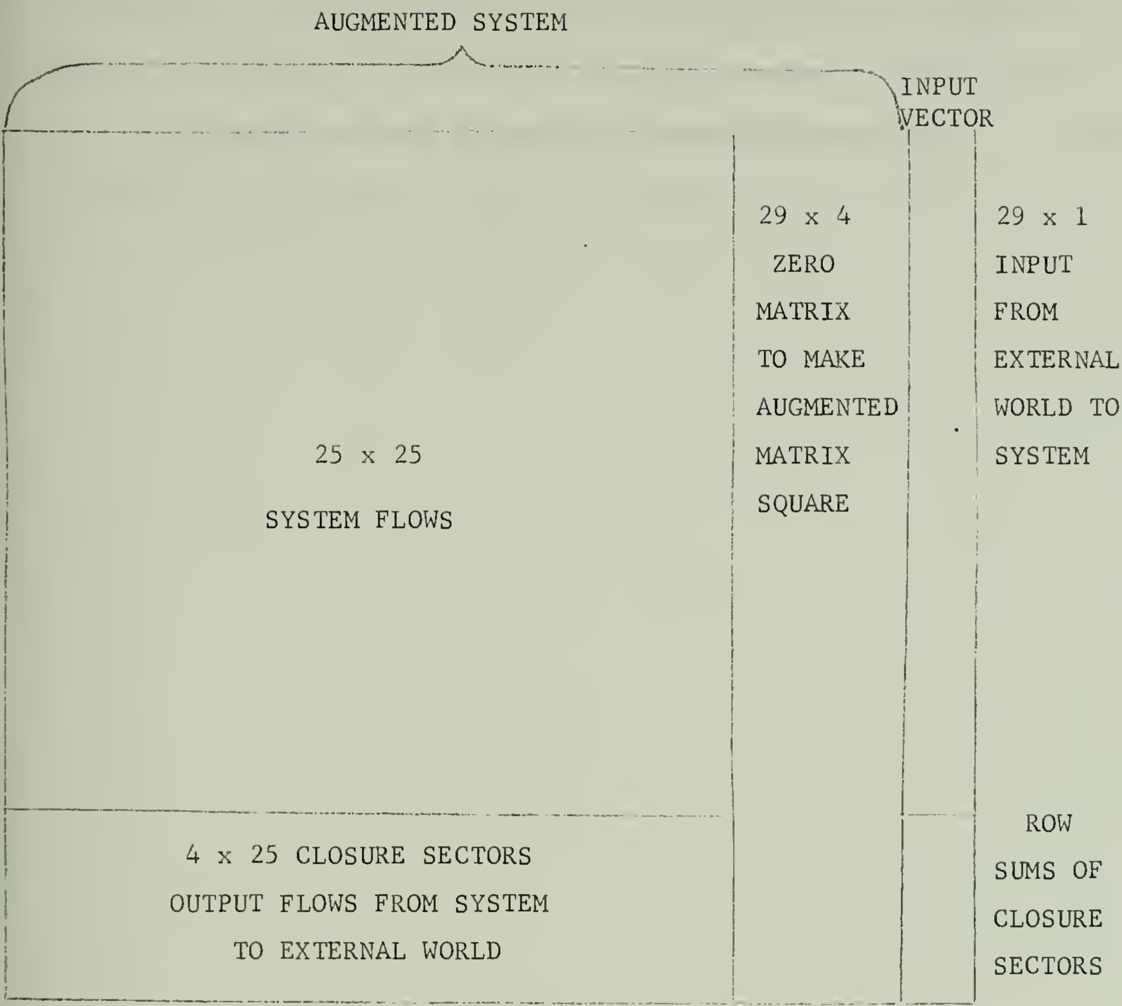

Figure 1

Design of Augmented System Matrix

the system plus the row sums of the closure sectors. In many cases, these are the numbers which management desires the model to produce. The inputs to the model are the desired outputs of the system for a given period and the outputs of the model are the required inputs to the system plus the flow volumes of intermediate products. A complete listing of the sectors is given in Table 1.

Table 1

Sector Definitions and Product Composition Assumptions

Sector	Product	Assumed Composition %Butterfat	%SNF
1	Contracted raw milk	3.8	8.65
2	Extra raw milk	3.8	8.65
3	Extra cream	38.0	5.5
4	Dry milk solids	--	97.0
5	Water	--	--
6	Sugar	--	--
7	Dextrose	--	--
8	Cocoa	--	--
9	Cream	38.0	5.5
10	Skim milk	0.1	9.0
11	Condensed skim milk	0.3	28.0
12	Buttermilk	0.1	9.0
13	Homogenized milk	3.6	8.67
14	Chocolate milk	3.36	8.1
15	Creamed buttermilk	1.8	8.8
16	Half-n-half	10.5	9.4
17	Butter	83.0	1.2
18	Ice cream mix	14.0	10.5
19	Ice cream	14.0	10.5
20	Ice milk mix	4.0	12.5
21	Sherbert	1.46	3.3
22	Sour cream	19.0	9.4
23	Cream cheese	35.0	19.0
24	Cottage cheese	4.6	40.0
25	Cheddar cheese	31.0	31.0
26	Shrinkage	varies as product	
27	Whey	varies as product	
28	Inventory	varies as product	
29	Output	varies as product	
30	Input	varies as product	

CHAPTER 3

PRODUCT FLOW PATTERNS

Before the actual determination of the flow patterns, several points must be clarified. Milk and milk products are of varying composition. Seldom do two batches of the same product have identical compositions. However, standard compositions are necessary to generate formulas which generally apply for planning purposes. Therefore, standard compositions of products are assumed as shown in Table 1. Historical data of the Penn State Creamery indicate an average overall shrinkage of 1.90% based on product pounds. Therefore, all formulas will include a loss factor of 1.90% of output volume except for the cheeses, where losses are included in the whey.* Shrinkage figures for the butterfat and solids not fat (SNF) formulas have been adjusted slightly to make formulas balance. Therefore, the composition of the shrinkage will not be quite the same as that of the output.

In the Penn State Creamery, the whey from cheese manufacture is discarded. This represents a large loss of butterfat and solid not

*Since shrinkage is related to processing, a more accurate relationship might be to assign a 0.5% shrinkage to fluid milk total volume; 1.0% shrinkage to the intermediate products total volume, such as cream, condensed skim milk, and buttermilk; 1.0% shrinkage to all non-whey products output volume; and no shrinkage to whey products but include butterfat and SNF analysis of whey as losses. This method would more accurately assign the loss where it actually occurs. This is easy to do in a linear flow model by assigning these values to the technical coefficients matrix. However, in the formula-generated transactions matrix being derived here, it becomes somewhat confusing and the simpler method described is used.

fat (SNF). In most commercial enterprises, the whey would be processed in some way to recover these valuable milk by-products. For this paper no shrinkage is assumed for those products in which the whey is discarded, and the losses which do occur are all considered part of the whey.

When used, dry milk solids usually replace condensed skim milk in the processing of various products. In order to standardize formulas, it is assumed that the dry milk solids are first converted to condensed skim milk by the addition of water and then used. In practice, the amount of skim milk in the formula is increased to provide the proper water content where necessary.

The Penn State Creamery operates on a batch process basis except for fluid milk operations. Therefore, most formulas are based on the batch sizes utilized. Once the batch formula is given, it is normalized by dividing by batch output weight or, in the case of the frozen products, the batch output volume. In addition, normalized (to product pound or product volume) formulas are given for calculating the flows of butterfat and SNF. The units for all formulas are pounds, even though it has been convenient to normalize some formulas to gallons. This convenience stems from the change in density during the packaging process and customer demand for frozen products is usually expressed in volume units.

A somewhat simplified flow diagram of the relationship between products is shown in Figure 2.

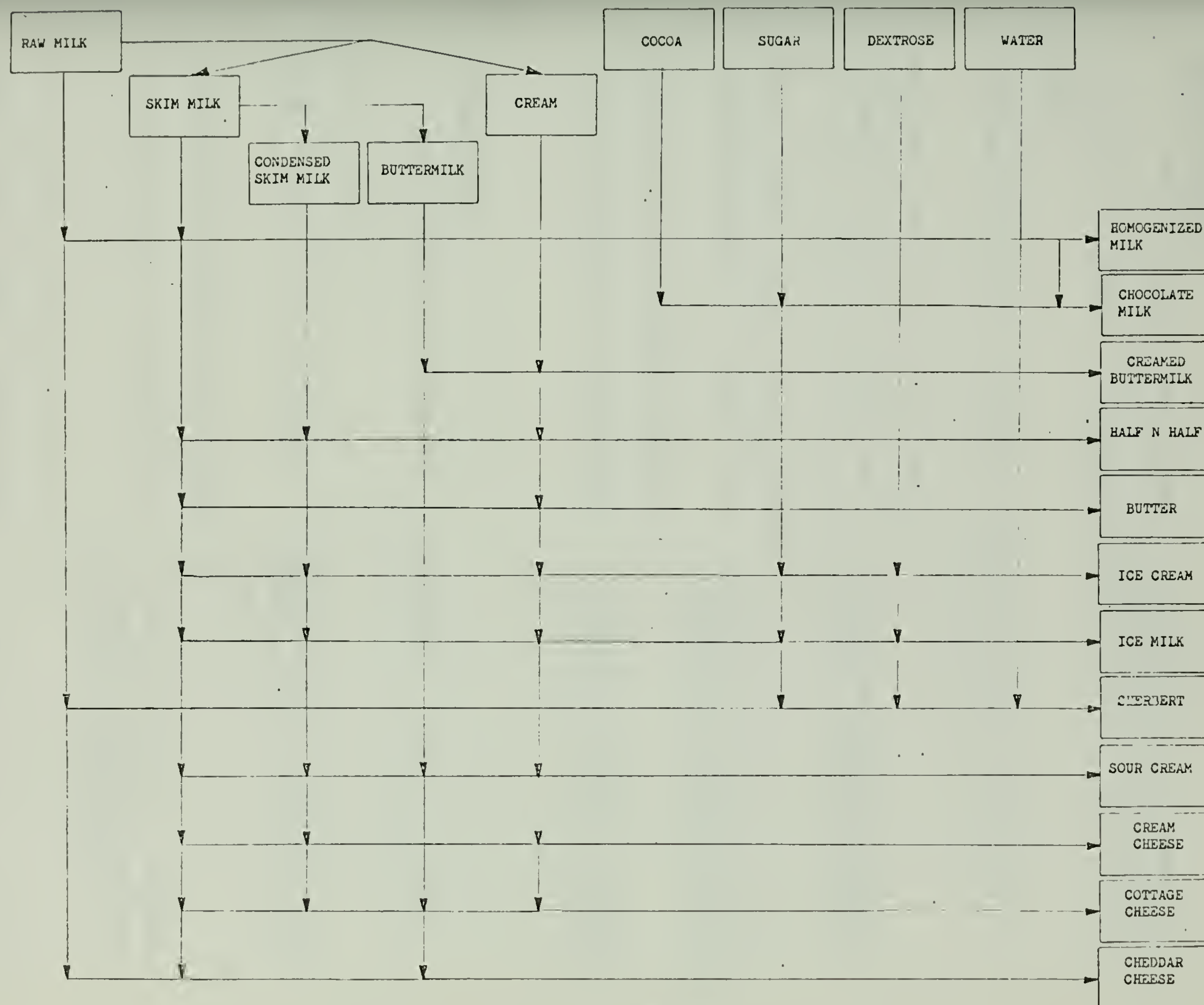

Figure 2

Flow Diagram of Creamery System

Cheddar Cheese

The batch size is 900 gallons of ingredients, which produces 726 pounds of cheese. The assumed production formula (neglecting salt added) is:

726# cheddar cheese + 7134# whey = 6518# raw milk + 1222# skim milk + 120# buttermilk

The normalized product pounds formula is:

1# cheddar cheese + 9.826446# whey = 8.977961# raw milk + 1.683196# skim milk + .1652892# buttermilk

The normalized butterfat pounds formula is:

.31# cheddar cheese + .0330109# whey = .3411625# raw milk + .0016832# skim milk + .0001653# buttermilk

The normalized SNF pounds formula is:

.31# cheddar cheese + .6329571# whey = .7765936# raw milk + .1514875# skim milk + .014876# buttermilk

Cottage Cheese

The batch size is 1100# of cottage cheese. The assumed production formula is:

1100# cottage cheese + 3992# whey = 4568# skim milk + 216# buttermilk + 216# condensed skim milk + 122# cream

The normalized product pounds formula is:

1# cottage cheese + 3.629091# whey = 4.125455# skim milk + .1963636# buttermilk + .1963636# condensed skim milk + .110909# cream

The normalized butterfat pounds formula is:

.046# cottage cheese + .0010563# whey = .0041255# skim milk + .0001964# buttermilk + .000589# condensed skim milk + .0421454# cream

The normalized SNF pounds formula is:

.40# cottage cheese + .0500453# whey = .3712909# skim milk + .0176727# buttermilk + .0549818# condensed skim milk + .006099# cream

Cream Cheese

The batch size is 433# cream cheese. The assumed production formula is:

433# cream cheese + 746# whey = 759# skim milk + 403# cream + 17# condensed skim milk

The normalized product pounds formula is:

1# cream cheese + 1.722864# whey = 1.752887# skim + .9307159# cream + .0392609# condensed skim milk

The normalized butterfat pounds formula is:

.35# cream cheese + .0055426# whey = .0017529# skim milk + .353672# cream + .0001177# condensed skim milk

The normalized SNF pounds formula is:

.19# cream cheese + .0301154# whey = .1577598# skim milk + .0508083# cream + .0115473# condensed skim milk

Sour Cream

The batch size is 10 gallons. The assumed production formula is:

78.9705# sour cream + 1.5295# shrinkage = 40# cream + 31# skim milk + 9# condensed skim milk + .5# buttermilk

The normalized product pounds formula is:

1# sour cream + .0193678# shrinkage = .5065182# cream + .3925516# skim milk + .1139666# condensed skim milk + .0063314# buttermilk

The normalized butterfat pounds formula is:

.19# sour cream + .0036799# shrinkage = .1929392# cream + .003926# skim milk + .0003418# condensed skim milk + .0000063# buttermilk

The normalized SNF pounds formula is:

.094# sour cream + .0018205# shrinkage = .0280105# cream + .0353296# skim milk + .0319106# condensed skim milk + .0005698# buttermilk

Sherbert

The batch size is 150 gallons of sherbert mix which, when packaged with an overrun of .33, yields 200 gallons of sherbert. Overrun is the change in volume due to injection of air during solidification. For frozen products it is convenient to normalize in terms of volume rather than weight because of the overrun. Additives are included in the weight of water. The assumed production formula is:

200 gallons = 1383.21# sherbert + 26.79# shrinkage = 540# raw milk + 300# dextrose + 180# cane sugar + 390# water

The normalized (to one gallon) product pounds formula is:

6.91605# sherbert + .13395# shrinkage = 2.7# raw milk + 1.5# dextrose + .9# cane sugar + 1.95# water

The normalized (to one gallon) butterfat pounds formula is:

.1009743# sherbert + .0016257# shrinkage = .1026# raw milk

The normalized (to one gallon) SNF pounds formula is:

.2282296# sherbert + .0053204# shrinkage = .23355# raw milk

Ice Milk Mix

Ice milk mix is sold instead of the finished product. The mix is used in machines at the point of consumption. The batch size for

ice milk mix is 300 gallons. Twenty four pounds of additives such as stabilizers, are subtracted from both sides of the formula to give an accurate ingredient ratio. Output is again normalized to gallons for convenience. The assumed production formula is:

300 gallons = 2625.156# ice milk mix + 50.844# shrinkage = 275# cream + 745# condensed skim + 1266# skim milk + 295# cane sugar + 95# dextrose

The normalized (to one gallon) product pounds formula is:

8.75052# ice milk mix + .1694798# shrinkage = .9166666# cream + 2.48333# condensed skim milk + 4.22# skim milk + .983333# sugar + .3166666# dextrose

The normalized (to one gallon) butterfat pounds formula is:

.3500208# ice milk mix + .0099824# shrinkage = .3483333# cream + .0074499# condensed skim milk + .00422# skim milk

The normalized (to one gallon) SNF pounds formula is:

1.093815# ice milk mix + .0317349# shrinkage = .0504166# cream + .6953333# condensed skim milk + .3798# skim

Ice Cream

The batch size for ice cream and ice cream mix is the same weight, but since packaged ice cream has an overrun of .833, the densities are different. This means the normalized (to one gallon) formulas will be different. Nine pounds of additives have been subtracted from both sides of the production formula to give accurate ingredient ratios. The production formula is:

550 gallons = 2639.871# ice cream + 51.129# shrinkage = 990# cream + 605# condensed skim milk + 656# skim milk + 340# sugar + 100# dextrose

The normalized (to one gallon) production formula is:

$$4.799765\# \text{ ice cream} + .092962\# \text{ shrinkage} = 1.8\# \text{ cream} + 1.1\# \text{ condensed skim milk} + 1.192727\# \text{ skim milk} + .6181818\# \text{ sugar} + .1818182\# \text{ dextrose}$$

The normalized (to one gallon) butterfat formula is:

$$.6719671\# \text{ ice cream} + .0165256\# \text{ shrinkage} = 684\# \text{ cream} + .0033\# \text{ condensed skim milk} + .0011927\# \text{ skim milk}$$

The normalized (to one gallon) SNF formula is:

$$.5039753 \text{ ice cream} + .0103701\# \text{ shrinkage} = .099\# \text{ cream} + .308\# \text{ condensed skim} + .1073454\# \text{ skim milk}$$

Ice Cream Mix

The batch size for ice cream mix is 300 gallons and it is also convenient to express output normalized to one gallon. Nine pounds of additives per batch have been subtracted from each side of the formula to give accurate ingredient ratios. The production formula is:

$$300 \text{ gallons} = 2639.871\# \text{ ice cream mix} + 51.129\# \text{ shrinkage} = 990\# \text{ cream} + 605\# \text{ condensed skim milk} + 656\# \text{ skim milk} + 340\# \text{ sugar} + 100\# \text{ dextrose}$$

The product pounds formula normalized to one gallon is:

$$8.79957\# \text{ ice cream mix} + .1704398\# \text{ shrinkage} = 3.3\# \text{ cream} + 2.016666\# \text{ condensed skim milk} + 2.186666\# \text{ skim milk} + 1.133333\# \text{ sugar} + .3333333\# \text{ dextrose}$$

The butterfat formula normalized to one gallon is:

$$1.231940\# \text{ ice cream mix} + .0302965\# \text{ shrinkage} = 1.254\# \text{ cream} + .0060499\# \text{ condensed skim milk} + .0021866\# \text{ skim milk}$$

The SNF pounds formula normalized to one gallon is:

$$.9239548\# \text{ ice cream mix} + .0190117\# \text{ shrinkage} = .1815\# \text{ cream} + .5646666\# \text{ condensed skim milk} + .1967999\# \text{ skim milk}$$

Butter

The butter churn has a capacity of 2100# on ingredients. Therefore, the batch size is that amount of butter made from 2100# of

ingredients or 832# of butter. Assume no shrinkage and the buttermilk goes to condensed skim milk for processing. The production formula is:

832# butter = 1824# cream + 276# skim milk - 1268# buttermilk to condensed skim milk

The normalized product pounds formula is:

1# butter = 2.192308# cream + .3317307# skim milk - 1.5240387# buttermilk to condensed skim milk

The normalized butterfat pounds formula is:

.83# butter = .8330768# cream + .0003317# skim milk - .0034085# buttermilk to condensed skim milk

The normalized SNF pounds formula is:

.012# butter = .1205769# cream + .0298557# skim milk - .1384326# buttermilk to condensed skim milk

Half-n-Half

The batch size is 50 gallons. The production formula is:

402# half-n-half + 8# shrinkage = 116# cream + 30# condensed skim milk + 274# skim milk

The normalized product pounds formula is:

1# half-n-half + .0194173# shrinkage = .2815533# cream + .0728155# condensed skim milk + .6650485# skim milk

The normalized butterfat pounds formula is:

.105# half-n-half + .0028736# shrinkage = .1069902# cream + .0002184# condensed skim milk + .000665# skim milk

The normalized SNF pounds formula is:

.094# half-n-half + .001728# shrinkage = .0154854# cream + .0203883# condensed skim milk + .0598543# skim milk

Creamed Buttermilk

The batch size is 10 gallons. The production formula is:

84.366# creamed buttermilk + 1.634# shrinkage = 82.15# buttermilk + 3.85# cream

The normalized product pounds formula is:

1# creamed buttermilk + .0193678# shrinkage = .9737334# buttermilk + .0456344# cream

The normalized butterfat pounds formula is:

.018# creamed buttermilk + .0003147# shrinkage = .0009737# buttermilk + .017341# cream

The normalized SNF pounds formula is:

.088# creamed buttermilk + .0021458# shrinkage = .087636# buttermilk + .0025098# cream

Chocolate Milk

The ingredients for chocolate milk are specified per 100 gallons of homogenized milk. The production formula is:

905# chocolate milk + 17# shrinkage = 860# homogenized milk + 12# cocoa + 50# sugar

The normalized product pounds formula is:

1# chocolate milk + .0187844# shrinkage = .9502762# homogenized milk + .0132596# cocoa + .0552486# sugar

The normalized butterfat pounds formula is:

.0336# chocolate milk + .0006099# shrinkage = .0342099# homogenized milk

The normalized SNF pounds formula is:

.081# chocolate milk + .0013889# shrinkage = .0823889# homogenized milk

Homogenized Milk

The production formula is:

1# homogenized milk + .019# shrinkage = .9653684# raw milk + .0536316# skim

The normalized butterfat pounds formula is:

.036# homogenized milk + .0007375# shrinkage = .0366839# raw milk + .0000536# skim milk

The normalized SNF pounds formula is:

.0867# homogenized milk + .0016311# shrinkage = .0835043# raw milk + .004826# skim milk

Note: In the program no shrinkage is assumed in processing homogenized milk for chocolate milk.

Buttermilk

In the Penn State Creamery, buttermilk is the name applied to that skim milk used to prepare cultures. Therefore, the production formula is:

1# buttermilk = 1# skim milk

The butterfat formula is: .001# buttermilk = .001# skim milk

The SNF formula is: .09# buttermilk = .09# skim milk

Condensed Skim Milk

The condensing process removes approximately two thirds of the weight as water evaporated away. The water will be considered as whey for output purposes. The batch size is 150 gallons. The production formula is:

1350# condensed skim milk + 2850# water = 4200# skim milk

The normalized product pounds formula is:

1# condensed skim + 2.111111# water = 3.111111# skim milk

The normalized butterfat formula is:

.003# condensed skim = .003# skim milk

The normalized SNF formula is:

.28# condensed skim milk = .28# skim milk

Dry Milk Solids

Dry milk solids are converted into condensed skim milk for the purposes of this model. The conversion process is:

1# condensed skim milk = .2886597# dry milk solids + .7113403# water

The normalized SNF formula is:

.28# condensed skim milk = .28# dry milk solids

Raw Milk

Raw milk is separated into cream and skim milk in accordance with the following formula:

1# raw milk = .097625# cream + .902375# skim milk

The normalized butterfat pounds formula is:

.038# raw milk = .0370975# cream + .0009025# skim milk

The normalized SNF pounds formula is:

.0865# raw milk = .0052863# cream + .0812137# skim milk

CHAPTER 4

PROGRAM TO GENERATE MATRIX

After the production formulas are standardized to establish the product ingredients and ingredient ratios, it is possible to calculate the required raw material and intermediate product flows to meet any output demand. A program (see Appendix A) has been written which, with only twenty numbers as inputs, will calculate the complete flow of material from input to output for any desired period. The twenty numbers include the desired outputs plus certain known, or easily estimated, system inputs. For instance, the existing inventories of cooler cream and condensed skim milk will be known or anticipated. Also, historical data on contracted milk supply for the period in question is a useful estimated input.

The output of the program includes a series of statements of interest to the user and three separate matrices; one based on product pounds as the flow unit, one based on butterfat pounds as the flow unit, and one based on solids not fat (SNF) pounds as the flow unit. Figures 3, 4, 5 and 6 show typical output of the program. Additionally this output may be punched to serve as input to a Penn State library program for input/output analysis.

Examining Figure 4, it can be seen in the first row of column 30 that 505600# of raw milk were inputed to the system during the month of May 1973. Looking down column 1, it can be seen that the raw milk went into five different products: 20896# to cream, 193155#

```
PENN STATE CREAMERY PRODUCTION PLANNING MODEL

PERIOD UNDER STUDY FOR THIS RUN IS
MONTH OF MAY 1973

COCOA REQUIRED FOR THIS PLANNING PERIOD =          535 POUNDS

DEXTROSE REQUIRED FOR THIS PERIOD =               2082 POUNDS

SUGAR REQUIRED FOR THIS PERIOD =                  8498 POUNDS

CONDENSED SKIM REQUIRED FOR THIS PERIOD =        13838 POUNDS
```

Figure 3

Typical Program Output, Information Page

PROD LBS	1 RAWMILK	2 EXTMILK	3 EXTCREM	4 DRYMILK	5 WATER	6 SUGAR	7 DEXTRSE	8 COCOA	9 CREAM	10 SKIM	11 CONDENS	12 BUTTRMK	13 HOMO	14 CHOCMLK	15 CRBUTMK
1 RAWMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 EXTMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 EXTCREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4 DRYMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 WATER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6 SUGAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 DEXTRSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 COCOA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 CREAM	20896	0	4313	0	0	0	0	0	0	0	0	0	0	0	0
10 SKIM	193155	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 CONDENS	0	0	0	0	0	0	0	0	0	52521	0	0	0	0	0
12 BUTTRMK	0	0	0	0	0	0	0	0	0	4697	0	0	0	0	0
13 HOMO	249658	0	0	0	0	0	0	0	0	13869	0	0	0	0	0
14 CHOCMLK	0	0	0	0	0	2232	0	535	0	0	0	0	38391	0	0
15 CRBUTMK	0	0	0	0	0	0	0	0	115	0	0	2463	0	0	0
16 HALFNHF	0	0	0	0	0	0	0	0	1305	3084	337	0	0	0	0
17 BUTTER	0	0	0	0	0	0	0	0	1775	268	0	0	0	0	0
18 ICECRMX	0	0	0	0	0	2719	800	0	7920	5247	4839	0	0	0	0
19 ICECREM	0	0	0	0	0	2180	641	0	6350	4207	3880	0	0	0	0
20 ICEMKMX	0	0	0	0	0	1218	392	0	1135	5228	3076	0	0	0	0
21 SHERBRT	448	0	0	0	323	149	249	0	0	0	0	0	0	0	0
22 SOURCRM	0	0	0	0	0	0	0	0	658	510	148	8	0	0	0
23 CREAMCH	0	0	0	0	0	0	0	0	2243	4224	94	0	0	0	0
24 COTTAGE	0	0	0	0	0	0	0	0	827	30775	1464	1464	0	0	0
25 CHEDDAR	41442	0	0	0	0	0	0	0	0	7769	0	762	0	0	0
26 SHRINK	0	0	0	0	0	0	0	0	0	1132	0	0	4197	758	49
27 WHEY	0	0	0	0	0	0	0	0	0	0	36476	0	0	0	0
28 INVENTY	0	0	0	0	0	0	0	0	8181	0	7794	0	0	0	0
29 OUTPUT	0	0	0	0	0	0	0	0	0	59624	0	0	220940	40400	2530

	16 HALFNHF	17 BUTTER	18 ICECRMX	19 ICECREM	20 ICEMKMX	21 SHERBRT	22 SOURCRM	23 CREAMCH	24 COTTAGE	25 CHEDDAR	26 SHRINK	27 WHEY	28 INVENTY	29 OUTPUT	30 INPUT
1 RAWMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	505600
2 EXTMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 EXTCREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4313
4 DRYMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 WATER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	323
6 SUGAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8498
7 DEXTRSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2082
8 COCOA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	535
9 CREAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5300
10 SKIM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 CONDENS	0	1234	0	0	0	0	0	0	0	0	0	0	0	0	3120
12 BUTTRMK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 HOMO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 CHOCMLK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 CRBUTMK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 HALFNHF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 BUTTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ICECRMX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 ICECREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 ICEMKMX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 SHERBRT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 SOURCRM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 CREAMCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 COTTAGE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 CHEDDAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 SHRINK	90	0	409	327	209	22	25	0	0	0	0	0	0	0	7218
27 WHEY	0	0	0	0	0	0	0	4152	27073	45358	0	0	0	0	113059
28 INVENTY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15975
29 OUTPUT	4638	810	21119	16933	10841	1148	1301	2410	7460	4616	0	0	0	0	394769

Figure 4

Typical Program Output, Product Pounds Transactions Matrix

BF LBS	1 RAWMILK	2 EXTMILK	3 EXTCREM	4 DRYMILK	5 WATER	6 SUGAR	7 DEXTRSE	8 COCOA	9 CREAM	10 SKIM	11 CONDENS	12 BUTTRMK	13 HOMO	14 CHOCMLK	15 CRBUTMK
1 RAWMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 EXTMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 EXTCREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4 DRYMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 WATER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6 SUGAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 DEXTRSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 COCOA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 CREAM	7940	0	1638	0	0	0	0	0	0	0	0	0	0	0	0
10 SKIM	193	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 CONDENS	0	0	0	0	0	0	0	0	0	52	0	0	0	0	0
12 BUTTRMK	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
13 HOMO	5487	0	0	0	0	0	0	0	0	13	0	0	0	0	0
14 CHOCMLK	0	0	0	0	0	0	0	0	0	0	0	0	1382	0	0
15 CRBUTMK	0	0	0	0	0	0	0	0	43	0	0	2	0	0	0
16 HALFNHF	0	0	0	0	0	0	0	0	495	3	1	0	0	0	0
17 BUTTER	0	0	0	0	0	0	0	0	674	0	0	0	0	0	0
18 ICECRMX	0	0	0	0	0	0	0	0	3009	5	14	0	0	0	0
19 ICECREM	0	0	0	0	0	0	0	0	2413	4	11	0	0	0	0
20 ICEMKMX	0	0	0	0	0	0	0	0	431	5	9	0	0	0	0
21 SHERBRT	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 SOURCRM	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0
23 CREAMCH	0	0	0	0	0	0	0	0	852	4	0	0	0	0	0
24 COTTAGE	0	0	0	0	0	0	0	0	314	30	4	1	0	0	0
25 CHEDDAR	1574	0	0	0	0	0	0	0	0	7	0	0	0	0	0
26 SHRINK	0	0	0	0	0	0	0	0	0	1	0	0	162	24	0
27 WHEY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 INVENTY	0	0	0	0	0	0	0	0	3108	0	23	0	0	0	0
29 OUTRUT	0	0	0	0	0	0	0	0	0	59	0	0	7953	1357	45

	16 HALFNHF	17 BUTTER	18 ICECRMX	19 ICECREM	20 ICEMKMX	21 SHERBRT	22 SOURCRM	23 CREAMCH	24 COTTAGE	25 CHEDDAR	26 SHRINK	27 WHEY	28 INVENTY	29 OUTRUT	30 INRUT
1 RAWMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19212
2 EXTMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 EXTCREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1638
4 DRYMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 WATER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6 SUGAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 DEXTRSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 COCOA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 CREAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2014
10 SKIM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 CONDENS	0	2	0	0	0	0	0	0	0	0	0	0	0	0	9
12 BUTTRMK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 HOMO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 CHOCMLK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 CRBUTMK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 HALFNHF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 BUTTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ICECRMX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 ICECREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 ICEMKMX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 SHERBRT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 SOURCRM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 CREAMCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 COTTAGE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 CHEDDAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 SHRINK	13	0	72	58	12	0	4	0	0	0	0	0	0	0	346
27 WHEY	0	0	0	0	0	0	0	13	7	152	0	0	0	0	172
28 INVENTY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3131
29 OUTPUT	486	672	2956	2370	433	16	247	843	343	1430	0	0	0	0	19210

Figure 5

Typical Program Output Butterfat Pounds Transactions Matrix

SNF LBS	1 RAWMILK	2 EXTMILK	3 EXTCREM	4 DRYMILK	5 WATER	6 SUGAR	7 OEXTRSE	8 COCOA	9 CREAM	10 SKIM	11 CONDENS	12 BUTTRMK	13 HOMO	14 CHOCMLK	15 CRBUTMK
1 RAWMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 EXTMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 EXTCREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4 DRYMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 WATER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6 SUGAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 OEXTRSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 COCOA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 CREAM	1149	0	237	0	0	0	0	0	0	0	0	0	0	0	0
10 SKIM	17383	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 CONDENS	0	0	0	0	0	0	0	0	0	4726	0	0	0	0	0
12 BUTTRMK	0	0	0	0	0	0	0	0	0	422	0	0	0	0	0
13 HOMO	21595	0	0	0	0	0	0	0	0	1248	0	0	0	0	0
14 CHOCMLK	0	0	0	0	0	0	0	0	0	0	0	0	3328	0	0
15 CRBUTMK	0	0	0	0	0	0	0	0	6	0	0	221	0	0	0
16 HALFNHF	0	0	0	0	0	0	0	0	71	277	94	0	0	0	0
17 BUTTER	0	0	0	0	0	0	0	0	97	24	0	0	0	0	0
18 ICECRMX	0	0	0	0	0	0	0	0	435	472	1354	0	0	0	0
19 ICECREM	0	0	0	0	0	0	0	0	349	378	1086	0	0	0	0
20 ICEMKMX	0	0	0	0	0	0	0	0	62	470	861	0	0	0	0
21 SHERBRT	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 SOURCRM	0	0	0	0	0	0	0	0	36	45	41	0	0	0	0
23 CREAMCH	0	0	0	0	0	0	0	0	123	380	26	0	0	0	0
24 COTTAGE	0	0	0	0	0	0	0	0	45	2769	409	131	0	0	0
25 CHEDDAR	3584	0	0	0	0	0	0	0	0	699	0	68	0	0	0
26 SHRINK	0	0	0	0	0	0	0	0	0	101	0	0	360	56	5
27 WHEY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 INVENTY	0	0	0	0	0	0	0	0	449	0	2182	0	0	0	0
29 OUTPUT	0	0	0	0	0	0	0	0	0	5366	0	0	19155	3272	222

	16 HALFNHF	17 BUTTER	18 ICECRMX	19 ICECREM	20 ICEMKMX	21 SHERBRT	22 SOURCRM	23 CREAMCH	24 COTTAGE	25 CHEDDAR	26 SHRINK	27 WHEY	28 INVENTY	29 OUTPUT	30 INPUT
1 RAWMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43734
2 EXTMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 EXTCREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	237
4 DRYMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 WATER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6 SUGAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 OEXTRSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 COCOA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 CREAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	291
10 SKIM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 CONDENS	0	112	0	0	0	0	0	0	0	0	0	0	0	0	873
12 BUTTRMK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 HOMO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 CHOCMLK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 CRBUTMK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 HALFNHF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 BUTTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ICECRMX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 ICECREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 ICEMKMX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 SHERBRT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 SOURCRM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 CREAMCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 COTTAGE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 CHEDDAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 SHRINK	8	0	45	36	39	0	2	0	0	0	0	0	0	0	652
27 WHEY	0	0	0	0	0	0	0	72	373	2921	0	0	0	0	3366
28 INVENTY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2631
29 OUTPUT	435	9	2217	1777	1355	37	122	457	2984	1430	0	0	0	0	38838

Figure 6

Typical Program Output SNF Pounds Transactions Matrix

to skim milk, 249658# to homogenized milk, 448# to sherbert, and 41442# to cheddar cheese. There is 1# lost in round-off error. Therefore, the flows are described from column to row. This convention is chosen to allow direct use of the matrix as the transactions matrix of a linear flow model.

Looking at the cream sector (sector 9) in detail, it can be seen by following row 9 across that 20896# came from raw milk (sector 1), 4317# came from extra cream (sector 3), and 5300# came from existing inventory from the previous period (sector 30). Following column 9 down it can be seen that 115# went into production of creamed buttermilk (sector 15), 1305# to half-n-half, 1775# to butter, etc., down to 8181# into inventory as cooler cream.

Looking at the input vector (sector 30) in detail, it can be seen that the first 25 numbers are the required raw materials. Naturally, sectors 13 through 25 will be zero since these are output products only. It can be seen that the program determined that 323# of water, 8498# of sugar, 2082# of dextrose, and 535# of cocoa were required in addition to the estimated inputs of contracted raw milk, extra cream, cooler cream inventory, and condensed skim milk inventory. The final four numbers are the closure totals, or the sums of the closure rows.

The same interpretation can be applied to the butterfat pounds matrix and the SNF pounds matrix, shown in Figures 5 and 6 respectively.

It is assumed that management can estimate the required demands for a given period. For the Penn State Creamery, the demand pattern can fluctuate radically due to changing student population. For instance, in October, which has no student breaks, the demand for

fluid milk products is high. For December, with Christmas vacation sending most students home, demand for fluid milk products is much lower. Also, as is true with any creamery, demand for frozen milk products increases in warm weather.

The period chosen as the base may be any convenient time breakdown. It is certainly advantageous to use monthly periods for accounting purposes, but it may be convenient to plan on a customer demand schedule, such as a school term, or quarter, for production purposes. Obviously, both can be done.

CHAPTER 5

EXAMPLE OF USE OF MATRIX

As a planning tool, the matrix can easily project requirements for future periods. As an example, assume that management wants to determine the required raw materials for a future quarter of operation, say third quarter, 1974. Assume that management can predict the customer demand for this period as follows: 150,000# skim milk, 800,000# homogenized milk, 200,000# chocolate milk, 3000# creamed buttermilk, 10,000# half-n-half, 4000# butter, 7000 gallons ice cream mix, 20,000 gallons ice cream, 2000 gallons ice milk mix, 500 gallons sherbert, 2500# sour cream, 10,000# cream cheese, 15,000# cottage cheese, and 10,000# cheddar cheese. Also management estimates that the contracted raw milk volume will be 1.2 million pounds and beginning of quarter inventories of cooler cream and condensed skim milk will be 500# and 1000# respectively.

The input to the program would be four punched IBM cards. The first card would contain a phrase describing the period under study; in this case "THIRD QUARTER - 1974".*

The second card would contain the first ten numbers of the program input corresponding to the following values expressed in pounds: 1) estimated contracted raw milk for the period under study, 2) estimated extra raw milk, 3) estimated extra cream, 4) estimated

---

*Note: Be sure first space of card is blank for carriage control purposes.

dry milk solids, 5) estimated cream inventory at beginning of period, 6) estimated condensed skim milk inventory at beginning of period, 7) predicted skim milk consumer demand, 8) predicted homogenized milk demand, 9) predicted chocolate milk demand, and 10) predicted creamed buttermilk demand. The numbers in this example are "1200000, 0, 0, 0, 500, 1000, 150000, 800000, 200000, 3000" in 10I8 format (FORTRAN IV). The third card would contain the last ten numbers of program input corresponding to predicted customer demand in pounds, except for frozen products, of: 11) half-n-half, 12) butter, 13) ice cream mix (in gallons), 14) ice cream (in gallons), 15) ice milk mix (in gallons), 16) sherbert (in gallons), 17) sour cream, 18) cream cheese, 19) cottage cheese, and 20) cheddar cheese. The numbers in this example are "10000, 4000, 7000, 20000, 2000, 500, 2500, 10000, 15000, 10000", also in 10I8 format. The fourth card contains the number of matrices wanted in punched card form, in this case - zero, in the first space.

When the program is run with this input, the information page is as shown in Figure 7, and the product pounds matrix is shown in Figure 8. From Figure 7, the following information for planning purposes can be extracted: to meet consumer demand for this quarter, the creamery will require 2,651 pounds of cocoa, 7,352 pounds of dextrose, 33,760 pounds of sugar, 39,820 pounds of cream beyond the contracted supply, and 6,244 pounds of dry milk solids. It has been determined that for internal use this period, 45,431 pounds of condensed skim milk will be required. Also it has been determined that if the extra cream and extra skim milk (dry milk solids) were obtained by purchasing additional raw milk, 407,887 pounds would be required. If this were

```
PENN STATE CREAMERY PRODUCTION PLANNING MODEL

PERIOD UNDER STUDY FOR THIS RUN IS
THIRD QUARTER 1974

COCOA REQUIRED FOR THIS PLANNING PERIOD =            2651 POUNDS

DEXTROSE REQUIRED FOR THIS PERIOD =                  7352 POUNDS

SUGAR REQUIRED FOR THIS PERIOD =                    33760 POUNDS

CONDENSED SKIM REQUIRED FOR THIS PERIOD =           45431 POUNDS

ADDITIONAL CREAM REQUIRED =                         39820 POUNDS
(THIS HAS BEEN ADDED TO ORIGINAL EXTRA CREAM ESTIMATE)

ADDITIONAL SKIM REQUIRED =                          67298 POUNDS
(THIS HAS BEEN CONVERTED TO DRY MILK SOLIDS AND
ADDED TO ORIGINAL DRY MILK SOLIDS INPUT FIGURE.
THIS EQUALS    6244 POUNDS ADDITIONAL DRY MILK
SOLIDS)

ALTERNATIVE SOURCE ADDITIONAL RAW MILK REQUIRED 407887 POUNDS
(THIS WOULD GIVE ADDITIONAL CONDENSED INVENTORY OF  96675 POUNDS)
```

Figure 7

Information Page - Example

PROD LBS	1 RAWMILK	2 EXTMILK	3 EXTCREM	4 ORYMILK	5 WATER	6 SUGAR	7 OEXTRSE	8 COCOA	9 CREAM	10 SKIM	11 CONOENS	12 BUTTRMK	13 HOMO	14 CHOCMLK	15 CRBUTMK
1 RAWMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 EXTMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 EXTCREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4 ORYMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 WATER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6 SUGAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 OEXTRSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 COCOA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 CREAM	44568	0	39820	0	0	0	0	0	0	0	0	0	0	0	0
10 SKIM	411957	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 CONDENS	0	0	0	6244	15387	0	0	0	0	45870	0	0	0	0	0
12 BUTTRMK	0	0	0	0	0	0	0	0	0	7533	0	0	0	0	0
13 HOMO	952346	0	0	0	0	0	0	0	0	52908	0	0	0	0	0
14 CHOCMLK	0	0	0	0	0	11049	0	2651	0	0	0	0	190055	0	0
15 CRBUTMK	0	0	0	0	0	0	0	0	136	0	0	2921	0	0	0
16 HALFNHF	0	0	0	0	0	0	0	0	2815	6650	728	0	0	0	0
17 BUTTER	0	0	0	0	0	0	0	0	8769	1326	0	0	0	0	0
18 ICECRMX	0	0	0	0	0	7933	2333	0	23100	15306	14116	0	0	0	0
19 ICECREM	0	0	0	0	0	12363	3636	0	36000	23854	22000	0	0	0	0
20 ICEMKMX	0	0	0	0	0	1966	633	0	1833	8440	4966	0	0	0	0
21 SHERBRT	1349	0	0	0	974	449	750	0	0	0	0	0	0	0	0
22 SOURCRM	0	0	0	0	0	0	0	0	1266	981	284	15	0	0	0
23 CREAMCH	0	0	0	0	0	0	0	0	9307	17528	392	0	0	0	0
24 COTTAGE	0	0	0	0	0	0	0	0	1663	61881	2945	2945	0	0	0
25 CHEDDAR	89779	0	0	0	0	0	0	0	0	16831	0	1652	0	0	0
26 SHRINK	0	0	0	0	0	0	0	0	0	2850	0	0	15200	3756	58
27 WHEY	0	0	0	0	0	0	0	0	0	0	80929	0	0	0	0
28 INVENTY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 OUTPUT	0	0	0	0	0	0	0	0	0	150000	0	0	800000	200000	3000

PROD LBS	16 HALFNHF	17 BUTTER	18 ICECRMX	19 ICECREM	20 ICEMKMX	21 SHERBRT	22 SOURCRM	23 CREAMCH	24 COTTAGE	25 CHEDDAR	26 SHRINK	27 WHEY	28 INVENTY	29 OUTPUT	30 INPUT
1 RAWMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1500000
2 EXTMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 EXTCREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39820
4 ORYMILK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6244
5 WATER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16361
6 SUGAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33760
7 DEXTRSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7352
8 COCOA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2651
9 CREAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
10 SKIM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 CONDENS	0	6096	0	0	0	0	0	0	0	0	0	0	0	0	1000
12 BUTTRMK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 HOMO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 CHOCMLK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 CRBUTMK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 HALFNHF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 BUTTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ICECRMX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 ICECREM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 ICEMKMX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 SHERBRT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 SOURCRM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 CREAMCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 COTTAGE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 CHEDDAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 SHRINK	194	0	1193	1859	338	66	48	0	0	0	0	0	0	0	25562
27 WHEY	0	0	0	0	0	0	0	17228	54436	98264	0	0	0	0	250857
28 INVENTY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 OUTPUT	10000	4000	61596	55995	17501	3458	2500	10000	15000	10000	0	0	0	0	1383050

Figure 8

Product Pounds Matrix - Example

done, the creamery would be overstocked with milk solids in the form of 96,675 pounds of condensed skim milk. This would occur because the extra cream requirement is high in relation to the extra skim requirement.

Depending on the creamery and the market, many alternatives are available. It may be advantageous to produce more of a product that uses skim milk, such as cottage cheese, and sell it on the open market; or it may be necessary to reduce estimated consumer demand by rationing or raising prices. At least the effects of the cumulative consumer demand on the total flows are presented by the matrix for analysis. For instance, by examining column 9 of Figure 8, it can be seen that primarily the extra cream is required for ice cream mix and ice cream (23100# for ice cream mix and 36000# for ice cream). Therefore, it would be futile to cut back on other products in an effort to reduce extra cream requirements significantly.

This aspect of the analysis of the model could provide an advantage over the traditional method of planning by rule of thumb or historical data. In addition, there are other advantages to being able to present the production flows in this manner. Bottlenecks due to excessive internal flow volumes can be spotted, especially if the time periods are short, such as weekly or daily. Production schedules could be shifted slightly to provide for smooth product flows.

Although not shown in this example monthly butterfat and SNF accounting data are easily checked by generating the matrices with actual outputs and inputs. With experience, other advantages should be apparent, since any possible combination of planning period and estimated inputs and outputs can be used.

CHAPTER 6

SUMMARY AND CONCLUSIONS

A planning matrix describing the flows of products through a creamery can be generated by straightforward application of standard production formulas. This management tool provides flexibility in determining alternatives and pointing out problem areas in attempting to meet predicted consumer demand. The matrix format is versatile in that the unit of flow can be product pounds, butterfat pounds, or solids not fat (SNF) pounds.

The model described in this paper is relatively crude in that it generates a transactions matrix for a given product ratio and for specified outputs. However, the format of the matrix is that required by linear flow model techniques and the power of the model could be extended greatly by applying those techniques. Since the product ratios are functions of time, expressions would have to be derived to simulate these changing ratios. Once that were done, a dynamic tool is available for strategic planning purposes. Impact studies could be done on the model to determine, in advance, effects on the system of changes in supply, in demand, in production levels, and in other influencing factors.

The format of a static linear flow model formed from the transactions matrix shown in Figure 4 is given in Figure 9 , which is the technical coefficients matrix, and in Figure 10, which is the interdependency coefficients matrix. This model assumes that the product

TECHNICAL COEFFICIENTS

		1	2	3	4	5	6	7	8
SECTOR	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	9	0.04132920	0.0	1.00000000	0.0	0.0	0.0	0.0	0.0
SECTOR	10	0.38203201	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	13	0.49378658	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	14	0.0	0.0	0.0	0.0	0.0	0.26265004	0.0	1.00000000
SECTOR	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	18	0.0	0.0	0.0	0.0	0.0	0.31995764	0.38424592	0.0
SECTOR	19	0.0	0.0	0.0	0.0	0.0	0.25653095	0.30787704	0.0
SECTOR	20	0.0	0.0	0.0	0.0	0.0	0.14332784	0.18828050	0.0
SECTOR	21	0.00088608	0.0	0.0	0.0	1.00000000	0.01753354	0.11959654	0.0
SECTOR	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	25	0.08196614	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 9

Typical Technical Coefficients Matrix Product Pounds Model

TECHNICAL COEFFICIENTS --CONTINUED

		9	10	11	12	13	14	15	16
SECTOR	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	11	0.0	0.27191116	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	12	0.0	0.02431726	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	13	0.0	0.07180244	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	14	0.0	0.0	0.0	0.0	0.14568091	0.0	0.0	0.0
SECTOR	15	0.00376938	0.0	0.0	0.52437726	0.0	0.0	0.0	0.0
SECTOR	16	0.04277426	0.01596645	0.00579955	0.0	0.0	0.0	0.0	0.0
SECTOR	17	0.05817955	0.00138749	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	18	0.25959553	0.02716471	0.08327597	0.0	0.0	0.0	0.0	0.0
SECTOR	19	0.20813530	0.02178044	0.06677222	0.0	0.0	0.0	0.0	0.0
SECTOR	20	0.03720214	0.02706635	0.05293591	0.0	0.0	0.0	0.0	0.0
SECTOR	21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	22	0.02156741	0.00264037	0.00254698	0.00170321	0.0	0.0	0.0	0.0
SECTOR	23	0.07351929	0.02186845	0.00161768	0.0	0.0	0.0	0.0	0.0
SECTOR	24	0.02710676	0.15932800	0.02519447	0.31168831	0.0	0.0	0.0	0.0
SECTOR	25	0.0	0.04022158	0.0	0.16223121	0.0	0.0	0.0	0.0
SECTOR	26	0.0	0.00586058	0.0	0.0	0.01592620	0.01841683	0.01899961	0.01903553
SECTOR	27	0.0	0.0	0.62772768	0.0	0.0	0.0	0.0	0.0
SECTOR	28	0.26815038	0.0	0.13412955	0.0	0.0	0.0	0.0	0.0
SECTOR	29	0.0	0.30868474	0.0	0.0	0.83839288	0.98158317	0.98100039	0.98096447

Figure 9 (Continued)

TECHNICAL COEFFICIENTS --CONTINUED

		17	18	19	20	21	22	23	24
SECTOR	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	11	0.60371820	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	26	0.0	0.01899940	0.01894554	0.01891403	0.01880342	0.01885370	0.0	0.0
SECTOR	27	0.0	0.0	0.0	0.0	0.0	0.0	0.63273392	0.78397475
SECTOR	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	29	0.39628180	0.98100060	0.98105446	0.98108597	0.98119658	0.98114630	0.36726608	0.21602525

Figure 9 (Continued)

TECHNICAL COEFFICIENTS --CONTINUEO

		25	26	27	28	29
SECTOR	1	0.0	0.0	0.0	0.0	0.0
SECTOR	2	0.0	0.0	0.0	0.0	0.0
SECTOR	3	0.0	0.0	0.0	0.0	0.0
SECTOR	4	0.0	0.0	0.0	0.0	0.0
SECTOR	5	0.0	0.0	0.0	0.0	0.0
SECTOR	6	0.0	0.0	0.0	0.0	0.0
SECTOR	7	0.0	0.0	0.0	0.0	0.0
SECTOR	8	0.0	0.0	0.0	0.0	0.0
SECTOR	9	0.0	0.0	0.0	0.0	0.0
SECTOR	10	0.0	0.0	0.C	0.0	0.0
SECTOR	11	0.C	0.0	0.0	0.0	0.0
SECTOR	12	0.0	0.0	0.0	0.0	0.0
SECTOR	13	0.0	0.0	0.0	0.0	0.0
SECTOR	14	0.0	0.0	0.0	0.0	0.0
SECTOR	15	0.0	0.0	0.0	0.0	0.0
SECTOR	16	0.0	0.0	0.0	0.0	0.0
SECTOR	17	0.0	0.0	0.0	0.0	0.0
SECTOR	18	0.C	0.0	0.0	0.0	0.0
SECTOR	19	0.0	0.0	0.0	0.0	0.0
SECTOR	20	0.0	0.0	0.0	0.0	0.0
SECTOR	21	0.0	0.0	0.0	0.0	0.0
SECTOR	22	0.0	0.0	0.0	0.0	0.0
SECTOR	23	0.C	0.0	0.0	0.0	0.0
SECTOR	24	0.0	0.0	0.0	0.0	0.0
SECTOR	25	0.0	0.0	0.0	0.0	0.0
SECTOR	26	0.0	0.0	0.0	0.0	0.0
SECTOR	27	0.90763197	0.0	0.0	0.0	0.0
SECTOR	28	0.0	0.0	0.0	0.0	0.0
SECTOR	29	0.09236803	0.0	0.0	0.0	0.0

Figure 9 (Continued)

INTERDEPENDENCY COEFFICIENTS

		1	2	3	4	5	6	7	8
SECTOR	1	1.00000000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	2	0.0	1.00000000	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	3	0.0	0.0	1.00000000	0.0	0.0	0.0	0.0	0.0
SECTOR	4	0.0	0.0	0.0	1.00000000	0.0	0.0	0.0	0.0
SECTOR	5	0.0	0.0	0.0	0.0	1.00000000	0.0	0.0	0.0
SECTOR	6	0.0	0.0	0.0	0.0	0.0	1.00000000	0.0	0.0
SECTOR	7	0.0	0.0	0.0	0.0	0.0	0.0	1.00000000	0.0
SECTOR	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00000000
SECTOR	9	0.04132920	0.0	1.00000000	0.0	0.0	0.0	0.0	0.0
SECTOR	10	0.38203201	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	11	0.10565042	0.0	0.03512406	0.0	0.0	0.0	0.0	0.0
SECTOR	12	0.00928997	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	13	0.52121741	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	14	0.07593143	0.0	0.0	0.0	0.0	0.26265004	0.0	1.00000000
SECTOR	15	0.00502723	0.0	0.00376938	0.0	0.0	0.0	0.0	0.0
SECTOR	16	0.00848025	0.0	0.04297797	0.0	0.0	0.0	0.0	0.0
SECTOR	17	0.00293458	0.0	0.05817955	0.0	0.0	0.0	0.0	0.0
SECTOR	18	0.02990431	0.0	0.26252052	0.0	0.0	0.31995764	0.38424592	0.0
SECTOR	19	0.02397740	0.0	0.21048062	0.0	0.0	0.25653095	0.30787704	0.0
SECTOR	20	0.01747045	0.0	0.03906146	0.0	0.0	0.14332784	0.18828050	0.0
SECTOR	21	0.00088608	0.0	0.0	0.0	1.00000000	0.01753354	0.11959654	0.0
SECTOR	22	0.00218498	0.0	0.02165687	0.0	0.0	0.0	0.0	0.0
SECTOR	23	0.01156385	0.0	0.07357611	0.0	0.0	0.0	0.0	0.0
SECTOR	24	0.06754608	0.0	0.02799169	0.0	0.0	0.0	0.0	0.0
SECTOR	25	0.09883920	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	26	0.01360603	0.0	0.01101225	0.0	0.01880342	0.01881690	0.01894330	0.01841683
SECTOR	27	0.21630057	0.0	0.09054722	0.0	0.0	0.0	0.0	0.0
SECTOR	28	0.02525328	0.0	0.27286156	0.0	0.0	0.0	0.0	0.0
SECTOR	29	0.74484012	0.0	0.62557898	0.0	0.98119658	0.98118310	0.98105670	0.98158317

Figure 10

Typical Interdependency Coefficients Matrix, Product Pounds Model

INTERDEPENDENCY COEFFICIENTS -- CONTINUED

		9	10	11	12	13	14	15	16
SECTOR	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	9	1.00000000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	10	0.0	1.00000000	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	11	0.03512406	0.27274881	1.00000000	0.0	0.0	0.0	0.0	0.0
SECTOR	12	0.0	0.02431726	0.0	1.00000000	0.0	0.0	0.0	0.0
SECTOR	13	0.0	0.07180244	0.0	0.0	1.00000000	0.0	0.0	0.0
SECTOR	14	0.0	0.01046024	0.0	0.0	0.14568091	1.00000000	0.0	0.0
SECTOR	15	0.00376938	0.01275142	0.0	0.52437726	0.0	0.0	1.00000000	0.0
SECTOR	16	0.04297797	0.01754827	0.00579955	0.0	0.0	0.0	0.0	1.00000000
SECTOR	17	0.05817955	0.00138749	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	18	0.26252052	0.04987813	0.08327597	0.0	0.0	0.0	0.0	0.0
SECTOR	19	0.21048062	0.03999248	0.06677222	0.0	0.0	0.0	0.0	0.0
SECTOR	20	0.03906146	0.04150455	0.05293591	0.0	0.0	0.0	0.0	0.0
SECTOR	21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	22	0.02165687	0.00337647	0.00254698	0.00170321	0.0	0.0	0.0	0.0
SECTOR	23	0.07357611	0.02230967	0.00161768	0.0	0.0	0.0	0.0	0.0
SECTOR	24	0.02799169	0.17377917	0.02519447	0.31168831	0.0	0.0	0.0	0.0
SECTOR	25	0.0	0.04416660	0.0	0.16223121	0.0	0.0	0.0	0.0
SECTOR	26	0.01101225	0.01032709	0.00400688	0.00999508	0.01860918	0.01841683	0.01899961	0.01903553
SECTOR	27	0.09054722	0.36165356	0.64850306	0.39160200	0.0	0.0	0.0	0.0
SECTOR	28	0.27286156	0.03658368	0.13412955	0.0	0.0	0.0	0.0	0.0
SECTOR	29	0.62557898	0.59143568	0.21336051	0.59840292	0.98139082	0.98158317	0.98100039	0.98096447

Figure 10 (Continued)

INTERDEPENDENCY COEFFICIENTS -- CONTINUED

		17	18	19	20	21	22	23	24
SECTOR	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	11	0.60371820	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	16	0.00350129	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	17	1.00000000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	18	0.05027522	1.00000000	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	19	0.04031160	0.0	1.00000000	0.0	0.0	0.0	0.0	0.0
SECTOR	20	0.03195837	0.0	0.0	1.00000000	0.0	0.0	0.0	0.0
SECTOR	21	0.0	0.0	0.0	0.0	1.00000000	0.0	0.0	0.0
SECTOR	22	0.00153766	0.0	0.0	0.0	0.0	1.00000000	0.0	0.0
SECTOR	23	0.00097662	0.0	0.0	0.0	0.0	0.0	1.00000000	0.0
SECTOR	24	0.01521036	0.0	0.0	0.0	0.0	0.0	0.0	1.00000000
SECTOR	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	26	0.00241902	0.01899940	0.01894554	0.01891403	0.01880342	0.01885370	0.0	0.0
SECTOR	27	0.39151310	0.0	0.0	0.0	0.0	0.0	0.63273392	0.78397475
SECTOR	28	0.08057645	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SECTOR	29	0.52509142	0.98100060	0.98105446	0.98108597	0.98119658	0.98114630	0.36726608	0.21602525

Figure 10 (Continued)

INTERDEPENDENCY COEFFICIENTS -- CONTINUED

		25	26	27	28	29
SECTOR	1	0.0	0.0	0.0	0.0	0.0
SECTOR	2	0.0	0.0	0.0	0.0	0.0
SECTOR	3	0.0	0.0	0.0	0.0	0.0
SECTOR	4	0.0	0.0	0.0	0.0	0.0
SECTOR	5	0.0	0.0	0.0	0.0	0.0
SECTOR	6	0.0	0.0	0.0	0.0	0.0
SECTOR	7	0.0	0.0	0.0	0.0	0.0
SECTOR	8	0.0	0.0	0.0	0.0	0.0
SECTOR	9	0.0	0.0	0.0	0.0	0.0
SECTOR	10	0.0	0.0	0.0	0.0	0.0
SECTOR	11	0.0	0.0	0.0	0.0	0.0
SECTOR	12	0.0	0.0	0.0	0.0	0.0
SECTOR	13	0.0	0.0	0.0	0.0	0.0
SECTOR	14	0.0	0.0	0.0	0.0	0.0
SECTOR	15	0.0	0.0	0.0	0.0	0.0
SECTOR	16	0.0	0.0	0.0	0.0	0.0
SECTOR	17	0.0	0.0	0.0	0.0	0.0
SECTOR	18	0.0	0.0	0.0	0.0	0.0
SECTOR	19	0.0	0.0	0.0	0.0	0.0
SECTOR	20	0.0	0.0	0.0	0.0	0.0
SECTOR	21	0.0	0.0	0.0	0.0	0.0
SECTOR	22	0.0	0.0	0.0	0.0	0.0
SECTOR	23	0.0	0.0	0.0	0.0	0.0
SECTOR	24	0.0	0.0	0.0	0.0	0.0
SECTOR	25	1.00000000	0.0	0.0	0.0	0.0
SECTOR	26	0.0	1.00000000	0.0	0.0	0.0
SECTOR	27	0.90763197	0.0	1.00000000	0.0	0.0
SECTOR	28	0.0	0.0	0.0	1.00000000	0.0
SECTOR	29	0.09236803	0.0	0.0	0.0	1.00000000

Figure 10 (Continued)

mix will be the same ratio irregardless of absolute volumes. It is the author's opinion that until the time fluctuation of the product mix is included in the model, the use of the model is restricted to historical checks only. The present program is the first step in attempting to obtain detailed information on how the flows change with product mix and product volume changes. Much work needs to be done in this area.

APPENDIX A

A COMPUTER PROGRAM FOR GENERATING THE FLOW MATRIX OF THE PENNSYLVANIA STATE UNIVERSITY CREAMERY

```
C THIS PROGRAM GENERATES A TRANSACTIONS MATRIX GIVEN DESIRED OUTPUTS FOR THE
C PENNSYLVANIA STATE UNIVERSITY CREAMERY
      REAL       REPCT(20)/3.,.7.,.2[illegible]
     15.,3.,16.,14.,6.,1.36,19.,35.,4.6,41.,438./,STAPCT(20)/3.55,4.65,[illegible]
     2.5,07.,4.0,.5,5.9.,29.,9.,[illegible]
     30,4.19.,40.,31.,280./
      INTEGER SECTOR(30),INPUT(20),F(10)/10*0/
      INTEGER P(21,20)/420*0/,Q(24,30)/720*0/,S(21,30)/630*0/
      INTEGER X(20)/20*0/,Y(20)/20*0/,Z(20)/20*0/
      REAL*8 TITLE(3)/'PROD USE','RE USE','[illegible]'/
      REAL*8 SECTOR(30)/'RAW MILK','EXT MILK','EXTERNAL','DRY MILK','LABOR',
     1'SUGAR','[illegible]','[illegible]','[illegible]','[illegible]','[illegible]',
     2'[illegible]','[illegible]','[illegible]','[illegible]','[illegible]','[illegible]',
     3'[illegible]','SHERBET','[illegible]','[illegible]','[illegible]','[illegible]',
     4'[illegible]','NOVELTY','OUTPUT','INPUT'/
      PRINT1
    1 FORMAT('1PENN STATE CREAMERY [illegible]')
      PRINT2
    2 FORMAT(' PERIOD UNDER STUDY FOR THIS RUN IS ')
      READ3
C FIRST DATA CARD SHOULD CONTAIN INFORMATION ABOUT THE PERIOD UNDER STUDY
    3 FORMAT('PERIOD UNDER STUDY DATA CARD. FIRST SPACE BLANK           ')
      PRINT3
C SECOND AND THIRD DATA CARDS SHOULD CONTAIN 20 INTEGERS IN I8 FORMAT CORRESPOND
C ING TO THE ORDER PRESENTED IN COMMENTS BELOW . ALL UNITS IN POUNDS EXCEPT AS
C NOTED.
      READ4,(INPUT(I),I=1,10)
      READ4,(INPUT(I),I=11,20)
    4 FORMAT(10I[illegible])
C ESTIMATED CONTRACTED RAW MILK FOR PERIOD UNDER STUDY
      P(1,20)=INPUT(1)
C ESTIMATED EXTRA MILK (NORMALLY ZERO)
      P(2,20)=INPUT(2)
C ESTIMATED EXTRA [illegible]
      P(3,20)=INPUT(3)
C EXISTING INVENTORY OF DRY MILK SOLIDS
      P(4,20)=INPUT(4)
C EXISTING [illegible]
      P([illegible])=INPUT(5)
C EXISTING INVENTORY OF [illegible] SKIM MILK
      P(11,20)=INPUT(6)
C SKIM MILK SALES REQUIRED FOR PERIOD UNDER STUDY
      P(20,10)=INPUT(7)
C [illegible] MILK [illegible]
      P(20,[illegible])=INPUT([illegible])
C CHOCOLATE MILK [illegible]
      P(20,1[illegible])=INPUT([illegible])
C CREAMED [illegible] MILK [illegible]
      P(20,15)=INPUT(10)
C HALF [illegible]
      P(20,16)=INPUT(11)
C BUTTER SALES [illegible]
      P(20,17)=INPUT(12)
C ICE CREAM [illegible] GALLONS
      P(20,18)=[illegible]
C ICE CREAM [illegible] GALLONS
      P(20,19)=4.[illegible]INPUT(14)
C ICE MILK [illegible] GALLONS
      P(20,20)=[illegible]INPUT(15)
C SHERBET [illegible] GALLONS
```

```
      P(20,21)=6.0160681 [illegible](15)
C SOUR CREAM POINT
      P(20,22)=INPUT(17)
C CREAM CHEESE POINT
      P(20,23)=INPUT(18)
C COTTAGE CHEESE POINT
      P(20,24)=INPUT(19)
C CHEDDAR CHEESE POINT
      P(20,25)=INPUT(20)
C FILLING IN TRANSACTIONS MATRIX USING FORMULAS BASED ON THESE GIVEN
C 7268 CHEDDAR CHEESE + [illegible] WHEY = [illegible] [illegible] MILK + 1223 SKIM [illegible] + 120
C BUTTER [illegible]
      P(25,1)=.0[illegible]P(20,25)
      P(25,10)=1.6[illegible]P(20,25)
      P(25,12)=.15[illegible]P(20,25)
      P(27,25)=1.0[illegible]P(20,25)
C 11035 COTTAGE CHEESE + 30[illegible] WHEY = 6553 SKIM MILK + 2166 BUTTER MILK + 216
C CONDENSED SKIM + 1[illegible] CREAM
      P(24,9)=.11[illegible]P(20,24)
      P(24,10)=4.1[illegible]P(20,24)
      P(24,11)=.104[illegible]P(20,24)
      P(24,12)=.10[illegible]P(20,24)
      P(27,24)=3.[illegible]P(20,24)
C 6330 CREAM CHEESE + [illegible] WHEY = 7596 SKIM + [illegible] CREAM + 11[illegible] SKIM
      P(23,9)=.0[illegible]P(20,23)
      P(23,10)=1.752[illegible]P(20,23)
      P(23,11)=.0202[illegible]P(20,23)
      P(27,23)=1.7[illegible]P(20,23)
C 78.17051 SOUR CREAM + 1.[illegible] SHRINKAGE = [illegible] CREAM + 31[illegible] SKIM + [illegible]
C SKIM + .5[illegible] BUTTER MILK
      P(22,9)=.[illegible]P(20,22)
      P(22,10)=.[illegible]P(20,22)
      P(22,11)=.11305[illegible]P(20,22)
      P(22,12)=.[illegible]P(20,22)
      P(26,22)=.01[illegible]67[illegible]P(20,22)
C 200 GAL = 1[illegible]3.21 [illegible] +26.700 SHRINKAGE = [illegible] MILK + [illegible] SK
C + 1838 SUGAR + [illegible]
      P(21,1)=2.[illegible]INPUT(15)
      P(21,[illegible])=1.[illegible](15)
      P(21,6)=.[illegible]INPUT(15)
      P(21,7)=1.[illegible]INPUT(15)
      P(26,21)=.13[illegible]INPUT(16)
C 300 GAL = 262[illegible].1[illegible] [illegible] + [illegible] SHRINKAGE = 27[illegible] CREAM + 74[illegible]
C CONDENSED SKIM + 126[illegible] SKIM MILK + 2[illegible] SUGAR + [illegible] DEXTROSE
      P(2[illegible],[illegible])=.[illegible]INPUT(15)
      P(2[illegible],7)=.71[illegible]INPUT(15)
      P(2[illegible],[illegible])=.0[illegible]INPUT(1[illegible])
      P(2[illegible],11)=[illegible].22 INPUT(1[illegible])
      P(20,11)=2.[illegible]INPUT(1[illegible])
      P(26,20)=.1666700[illegible]INPUT(15)
C 350 GAL = [illegible] + 51.120 [illegible] = [illegible] CREAM + [illegible]
C CONDENSED SKIM + [illegible] SKIM + [illegible] SUGAR + [illegible] DEXTROSE
      P(19,6)=.6[illegible]INPUT(14)
      P(19,7)=.1[illegible]INPUT(14)
      P(19,9)=1.[illegible]INPUT(14)
      P(19,1[illegible])=1.[illegible]727 INPUT(14)
      P(1[illegible],11)=1.1[illegible]INPUT(14)
      P(26,19)=.0[illegible]INPUT(14)
C 300 GAL = 2570.71[illegible] ICE CREAM [illegible] + 51.12[illegible] SHRINKAGE = 900 CREAM + [illegible]
C CONDENSED SKIM + 656[illegible] SKIM + 3600 SUGAR + [illegible] DEXTROSE
```

```
      P(18.6)=1.[illegible]*OUT(13)
      P(18.7)=OUTPUT(13)/[illegible]
      P(18.9)=3.[illegible]*OUT(13)
      P(18.10)=2.1666666*OUT(13)
      P(18.11)=2.0166666*OUT(13)
      P(26.18)=.17[illegible]*OUT(13)
C 832# BUTTER + 1268# BUTTERMILK TO CONDENSED SKIM = 1826# CREAM + 2[illegible]# SKIM
      P(17.9)=2.[illegible]*P(20.17)
      P(17.13)=.2317307*P(20.17)
      P(11.17)=1.5240390*P(20.17)
C 412# HALF N HALF + [illegible] SHRINKAGE = 116# CREAM + 30# CONDENSED SKIM + 274# SKIM
      P(16.9)=.2[illegible]*P(20.16)
      P(16.10)=.[illegible]*P(20.16)
      P(16.11)=.0[illegible]*P(20.16)
      P(26.16)=.0[illegible]*P(20.16)
C 84.366# CREAM[illegible] BUTTERMILK +[illegible].634# SHRINKAGE = 82.154 BUTTERMILK + 3.85#
C CREAM
      P(15.1)=.[illegible]*P(20.15)
      P(15.12)=.0737336*P(20.15)
      P(26.15)=.[illegible]*P(20.15)
C 905# CHOCOLATE MILK + 17.[illegible] SHRINKAGE = [illegible] HOMOGENIZED MILK + 12 COCOA +
C 50# SUGAR
      P(14.6)=.0552[illegible]*P(20.14)
      P(14.8)=.0132506*P(20.14)
      P(14.13)=.[illegible]*P(20.14)
      P(26.14)=.01[illegible]*P(20.14)
C 1# HOMOGENIZED MILK + .[illegible]# SHRINKAGE = .9553[illegible] RAW MILK + .[illegible] SKIM
      P(13.1)=.9553[illegible]*P(20.13)+.9473[illegible]*P(14.13)
      P(13.10)=.0[illegible]*P(20.13)+.0526316*P(14.13)
      P(26.13)=.010*P(20.13)
C 1# BUTTERMILK = 1# SKIM
      P(12.10)=P([illegible].12)+P(22.12)+P(24.12)+P(25.12)
C 12500# CONDENSED SKIM + [illegible] WATER ([illegible]) = 52000 SKIM
C K(1)= CONDENSED [illegible] FOR PROCESSING
C K(2)= CONDENSED [illegible] FROM SKIM
C NOTE: P(11.4) + P(11.5) = CONDENSED [illegible] SOLIDS
    5 P(11.3)=P(6.30)
      P(11.5)=.[illegible]*P(6.30)
      K(1)=P(16.11)+P(1[illegible].11)+P(1[illegible].11)+P(2[illegible].11)+P(22.11)+P(23.11)+[illegible](24.11
     1)
      K(2)=K(1)-P(11.4)-P(11.5)-P(11.30)-P(11.17)
      P(11.10)=3.[illegible]*K(2)-P(11.17)
      P(27.11)=2.[illegible]*K(2)
C [illegible]
C K(3)= [illegible] SKIM [illegible] PROCESSING
      P(26.10)=.01[illegible]*P(20.17)
      K(3)=P(11.10)+P(1[illegible].10)+P(1[illegible].10)+P(15.10)+P(17.10)+P(1[illegible].10)+P(1[illegible].10
     1)+P(20.10)+P(22.10)+P(23.10)+P(24.10)+P(25.10)+P(25.10)+[illegible]
C K(4)= [illegible] CREAM [illegible] PROCESSING
      P(9.3)=P(4.30)
      K(4)=P(1[illegible].9)+P(1[illegible].9)+P(17.9)+P(1[illegible].9)+P(1[illegible].9)+P(20.9)+P(22.9)+P([illegible].
     1)+P(24.9)
      P(1.2)=P(1.31)
      P(1.30)=P(14.3)
      PRINT6,P([illegible])
    6 FORMAT([illegible])
     1S1)
      P(7.30)=P(19.7)+P(18.7)+P(2[illegible].7)+P(21.7)
      PRINT7,P(7.30)
    7 FORMAT([illegible])
```

```
      P(6,29)=P(1?,6)+P(1?,6)+P(1?,6)+P(20,6)+P(21,6)
      PRINT 9,P(6,29)
    9 FORMAT('0SI... [illegible] FOR THIS PERIOD =',T50,I5,' POUNDS')
      PRINT 0,X(1)
    0 FORMAT('0COOKED-SEED SKIM REQUIRED FOR THIS PERIOD =', T50,I5,' POUN
     1DS')
      P(6,20)=P(21,6)+P(11,6)
C X(5)= AVAILABLE [illegible] FOR SEPARATION
      X(5)=P(1,30)+P(3,2)-P(19,1)-P(21,1)-P(25,1)
C DETERMINE IF EXTRA [illegible] IS REQUIRED
      X(6)=X(4)-P(9,3 )-P(3,20)
      IF(X(6).LT.0. [illegible]) GO TO 10
C DETERMINE [illegible] CREAM INVENTORY
      P(9,1)=.0076[illegible]
      P(2?,9)=P(9,1)-X(6)
      GO TO 12
C X(7)= [illegible] CREAM [illegible]
   10 X(7)=X(6)-.0076[illegible]X(5)
      P(9,1)=.0076[illegible]X(5)
      P(3,30)=P(3,30)+X(7)
      P(9,3)=P(3,30)
      PRINT 11,X(7)
   11 FORMAT([illegible] =',T50,I5,' POUNDS'/' (THIS HAS
     1 BEEN ADDED TO [illegible] EXTRA [illegible])')
C DETERMINE IF EXTRA SKIM IS [illegible]
   12 IF (X(3).GT.0.00227[illegible]X(5))GO TO 13
      P(10,1)=0.00227[illegible]X(5)
C EXTRA SKIM GETS [illegible]
      P(11,10)=P(11,10)+.00227[illegible]X(5)-X(3)
      P(27,11)=P(27,11)+.6[illegible]71[illegible](.00227[illegible]X(5)-X(3))
      P(24,11)=.[illegible](.00227[illegible]X(5)-X(3))
      GO TO 30
   13 X(8)=X(3)-.00227[illegible]X(5)
      P(10,1)=.00227[illegible]X(5)
C ADDITIONAL SKIM [illegible] IS [illegible] SOLIDS
      P(11,10)=P(11,10)-X(8)
C CHECK FOR [illegible]
      IF(P(11,10).[illegible]) GO TO 15
      X(9)=-P(11,10)
      PRINT 15,X(9)
   15 FORMAT([illegible]
     1[illegible]
     2[illegible] IS [illegible]
     3[illegible])
C [illegible] IF THIS [illegible]
C [illegible]
      [illegible]
C [illegible]
   16 P(6,[illegible])=[illegible].111111) [illegible]
     1 P(6,20)=P(6,20)+(X( )/7.111111)*.711[illegible]
      P(11,3)=P(6,20)
      P(11,5)=P(11,5)+(X(9)/7.111111)*.711[illegible]
      [illegible]
   1? [illegible] IS [illegible]
     1 [illegible]
     2 [illegible]'/' THIS AMOUNTS [illegible]
     3 [illegible])
   40 IF([illegible])
      IF([illegible])
   41 IF(P(6,?)*.01[illegible]/.002[illegible])
```

```
17 X(11)=X(8)/.002476
   XL=X(10)*.004625-X(7)
   PRINT20,X(10),XL
20 FORMAT(1OALTERNATIVE SOURCE ADDITIONAL RAW STOCK REQUIRED =',F50.1,
  1' POUNDS'/' (THIS WOULD GIVE ADDITIONAL GREASE INVENTORY OF ',F5.1,
  2 POUNDS)')
   GO TO 90
18 X(10)=X(9)/.002375
   PRINT21, X(10)
21 FORMAT('ALTERNATIVE SOURCE ADDITIONAL RAW STOCK REQUIRED =',F50.1,
  1' POUNDS'/' (THIS IS PERFECT BALANCE, YIELDS BOTH GREASE & [illegible]
  2)')
   GO TO 90
19 X(10)=X(7)/.00462
   XL=(X(10)*.002376-X(9))/.111111
   PRINT22, X(10),XL
22 FORMAT('OALTERNATIVE SOURCE ADDITIONAL RAW STOCK REQUIRED =',F50.1,
  1' POUNDS'/' (THIS WOULD GIVE ADDITIONAL [illegible] INVENTORY OF ',F
  2?15.1' POUNDS)')
90 GO TO [illegible]
C DETERMINE [illegible]
   DO 500 [illegible]
   DO 500 I=1,20
500 P(I,30)=P(I,?)+P(I,1)
C PRINTING OUT PRODUCT [illegible] TRANSACTIONS [illegible]
   PRINT90
90 FORMAT('1')
91 FORMAT('0')
92 FORMAT('+')
93 FORMAT(' ')
   PRINT91
   PRINT93
   DO 95 I=1,[illegible]
95 [illegible]
   [illegible]
100 [illegible]
   PRINT[illegible]
101 [illegible]
   [illegible]
102 [illegible]
   DO 103 I=1,20
103 PRINT104,I,[illegible](I),(P(I,II),II=1,1[illegible])
104 FORMAT(' ',I2,1X,[illegible])
   PRINT[illegible]
105 FORMAT([illegible])
   PRINT[illegible](I),I=1,20)
   DO [illegible] I=1,20
106 PRINT[illegible]
C PRINTING OUT [illegible]
   PRINT[illegible]
   [illegible]
   [illegible]
   [illegible] I=1,1[illegible]
96 [illegible]
   DO 107 I=1,[illegible]
107 [illegible]
   DO [illegible] I=1,[illegible]
   P(I,30)=[illegible]
   DO [illegible] I=1,20
108 [illegible](I,1)=[illegible]P(I,1)
```

```
      R(9,1)=.2[illegible]R(9,1)
      R(10,1)=.[illegible]R(10,1)
      R(27,11)=0
      R(11,17)=.0[illegible]R(11,17)
      R(27,23)=.00[illegible]R(27,23)
      R(27,24)=.00[illegible]R(27,24)
      R(27,25)=.0[illegible]R(27,25)
      R(26,21)=.0121366 R(26,21)
      R(26,20)=.[illegible]R(26,20)
      R(26,19)=.17776[illegible]R(26,19)
      R(26,18)=.1777[illegible]R(26,18)
      R(26,16)=.15[illegible]R(26,16)
      R(26,15)=.[illegible]R(26,15)
      R(26,14)=.[illegible]R(26,14)
      R(26,13)=.[illegible]R(26,13)
C DETERMINE [illegible]
      DO 501 I=26,30
      DO 501 J=1,2[illegible]
  501 R(I,30)=[illegible]
      PRINT 101,TITLE(2),[illegible](I),I=1,15)
      PRINT 102,([illegible](I),I=1,15)
      DO 100 I=1,2[illegible]
  100 PRINT 104,I,SECTOR(I),(R(I,J),J=1,15)
      PRINT 105,([illegible](I),I=16,30)
      PRINT 102,(SECTOR(I),I=16,30)
      DO 110 J=1,2[illegible]
  110 PRINT 104,I,SECTOR(I),(R(I,J),I=16,30)
C PRINTING OUT S = [illegible] TRANSACTIONS MATRIX
      PRINT 106
      PRINT 107
      PRINT 1[illegible]
      DO 97 I=1,11
   97 PRINT 102
      DO 111 J=1,2[illegible]
  111 S[illegible]T(J)=.[illegible]T(J)
      DO 112 J=1,2[illegible]
      S(1,30)=S[illegible]T(J)[illegible](J,30)
      DO 112 I=1,[illegible]
  112 S(I,J)=[illegible]T(J)*R(I,J)
      S(9,1)=.[illegible](9,1)
      S(10,1)=.[illegible]R(10,1)
      S(27,11)=0
      S(11,17)=.[illegible](11,17)
      S(27,23)=.[illegible](27,23)
      S(27,24)=.[illegible](27,24)
      S(27,25)=.[illegible](27,25)
      S(26,22)=.[illegible](26,22)
      S(26,21)=.[illegible](26,21)
      S(26,20)=.1[illegible](26,20)
      S(26,19)=.111[illegible](26,19)
      S(26,18)=.11[illegible](26,18)
      S(26,16)=.[illegible](26,16)
      S(26,15)=.11[illegible](26,15)
      S(26,14)=.0[illegible]R(26,14)
      S(26,13)=.[illegible](26,13)
C DETERMINE [illegible]
      DO 502 I=26,[illegible]
      DO 502 J=1,[illegible]
  502 S(I,40)=S(I,[illegible])+[illegible](I,J)
      PRINT 101,TITLE( ),(S[illegible](I),I=1,1[illegible])
```

```
      PRINT102,(S[illegible](I),I=1,15)
      DO 113 J=1,2
  113 PRINT104,J,[illegible](J),(S(J,I),I=1,15)
      PRINT105,(S[illegible](I),I=16,30)
      PRINT102,(S[illegible](I),I=16,30)
      DO 114 J=1,20
  114 PRINT104,J,SECTOR(J),(S(J,I),I=16,20)
C FOURTH DATA CARD CONTAINS A [illegible] OR 3 IN THE FIRST COLUMN DEPENDING ON THE
C NUMBER OF MATRICES PUNCHED.
C CHECK TO SEE IF [illegible] OUTPUT IS DESIRED.
      READ 602, [illegible]
  602 FORMAT(I1)
      IF([illegible]) GO TO [illegible]
C X,Y,Z ARE TOTAL ACTIVITY VECTORS FOR THE THREE MATRICES
      DO 600 I=1,20
      DO 600 J=1,20
      X(I)=X(I)+[illegible](J,I)
      Y(I)=Y(I)+[illegible](J,I)
  600 Z(I)=Z(I)+[illegible](J,I)
C CHECK THAT TOTAL ACTIVITY VECTOR CONTAINS [illegible] ZEROS
      DO 700 I=1,20
      IF(X(I).GT.0)GO TO 701
      X(I)=1
  701 IF(Y(I).GT.0) GO TO 702
      Z(I)=1
  702 IF(Z(I).GT.0) GO TO 700
      Z(I)=1
  700 CONTINUE
C THIS SET OF CARDS IS FOR PRODUCT MOMENTS MATRIX IN F10.1 FORMAT. FIRST
C [illegible] CARDS ARE TOTAL ACTIVITY VECTOR. NEXT FOUR ARE FIRST ROW OF [illegible]
C MATRIX. NEXT FOUR ARE SECOND [illegible], ETC. THESE CARDS MAY BE [illegible] USED
C DIRECTLY AS INPUT [illegible] THE [illegible] PROGRAM [illegible]
      PUNCH603,(X(I),I=1,20)
  603 FORMAT(8(F10.1,[illegible]))
      DO 604 I=1,20
  604 PUNCH603,(R(I,J),J=1,20)
      IF([illegible]) [illegible]
C THIS SET OF CARDS [illegible]
  902 STOP
      END
```

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